REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
1990

3. REPORT TYPE AND DATES COVERED
Final 1 Feb 87 - 31 Jan 90

4. TITLE AND SUBTITLE
Nonlinear Real-Time Signal Processing

5. FUNDING NUMBERS
DAAL03-87-K-0026

6. AUTHOR(S)
William A. Porter

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Louisiana State Univ
Baton Rouge, LA 70803

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U. S. Army Research Office
P. O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
ARO 24962.13-MA

11. SUPPLEMENTARY NOTES
The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

The grant supported in part a research effort in Nonlinear Real-Time Signal Processing. The effort was composed of three interacting lines of development: advances in array processing, advances in fast algorithmic forms, applications of the above to polynomic and m-D signal processing algorithms.

14. SUBJECT TERMS
Signal Processing, Array Processing, Fast Algorithmic Forms, Signal Processing Algorithms, Algorithms

15. NUMBER OF PAGES
4

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

90 06 14 139

ARO 24962.13-MA

NONLINEAR REAL–TIME SIGNAL PROCESSING

FINAL REPORT

Dr. William A. Porter

June 1, 1990

U. S. Army Research Office

DAAL03–87–K–0026/24962–MA–SDI

Louisiana State University
Baton Rouge, LA. 70803

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED

The subject grant supported in part a research effort in Nonlinear Real–Time Signal Processing. The effort was composed of three interacting lines of development: advances in array processing, advances in fast algorithmic forms, applications of the above to polynomic and m–D signal processing algorithms. To give a more complete, but concise, flavor of the results we list the abstracts of selected publications supported under the grant.

Generalized Distributive Memory Arrays. In recent years neuroanatomical models of brain functioning have given an impetus to the development of structures with associative (often called distributive) memory. Such structures were referred to generically as neural networks. In the initial studies of neural networks the processing nodes emulated neurons while the connecting linkages emulated synaptic channels. In the present study we consider the DWM in a generality not heretofore attempted. We considered arbitrary nonlinearities (as contrasted to the sgn function or the polynomic functions) and identify the minimal properties that such functions must satisfy.

Computational Aspects of Quadratic Signal Processing. In recent years, problems of speech processing, data clustering, pattern recognition, chaotic dynamics, and neural computing have stimulated interest in quadratic signal processing. Unfortunately, quadratic signal processing is often computationally more intense than the linear case, and hence, attention to concurrent computation is an important concern, particularly in real–time applications. The present study addresses the concurrent computation issue in the context of systolic array processors. The study makes use of recent results in fast form algorithms and their implementation via dynamically switchable systolic arrays.

Polyarrays as Distributed Memory Recognition Function. In recent years neuroanatomical models of the brain have given an impetus to the development of neural networks. The processing nodes in such structures emulate 'neurons' and the connection linkages emulate

the role of 'synaptic channels'. The instantaneous state of neural network is generally taken to be the collective state of the structure neurons. In this study we summarize some results of polynomic recognition functions. This class of functions has been researched in earlier studies and provides the necessary connection between neural and systolic computing. We demonstrate the implementation of polynomic functions on a systolic array. As this development unfolds it will become apparent that polyarrays (i.e. polynomic recognition functions on systolic arrays) represent an alternative to neural networks for distributed memory recognition.

Fast Forms of Banded Maps. In real–time applications, computation speed can be a critical factor in the success of signal processing algorithms. The systolic array provides the potential for computational parallelism, and the implementation of algorithms on such arrays has been widely studied. The present research is a continuation of earlier work which identified decomposition techniques for linear algorithms. The resultant concurrent triple product structure is tested here on the class of maps which are diagonally banded. The banded maps include Toeplitz, convolution, and Hilbert transform operations, each of which is considered in the study.

Fast 2–D Signal Processing. This study considers linear maps on a 2–D signal space. Using recent results on fast linear transforms several categories of fast 2–D maps are identified. The connections between fast processing and types of kernel separability are developed. Companion systolic architectures which efficiently realize the fast forms are discussed. The transfer functions of fast 2–D processors are analyzed and illustrated through example.

Concurrent Forms of Signal Processing Algorithms. This study is concerned with forms of algorithms that facilitate rapid processing on affiliated systolic arrays. One thrust of the development identifies classes of linear maps $A: E^n \to E^n$ that can be computed on $p \times p$

arrays at speed O(p) where $p = \sqrt{n}$. The array architectures which provide the requisite computational support are identified. A second thrust considers the expansion of arbitrary linear maps in terms of the fast maps. The results include a definitive method for minimal expansions and for best approximations of an *a priori* order. The study closes with a detailed comparative example which illustrates the principles of question.